[0113] Five strands **163** are used to form the individual SMA members **194** of FIG. **5**C. The individual SMA members **194** also include the matrix **166**. However, in this embodiment, the matrix **166** completely covers and surrounds the strands **163**. To form the composite SMA member **192**, the individual SMA members **194** are stacked and layered in, as an illustrative example, a bricklayer pattern.

[0114] In addition to the straight-wire type of SMA working members, other configurations of SMA working members may be used with the heat engine **14** or with other heat engines. For example, and without limitation, SMA working elements may be formed as springs or ribbons, may be braided or weaved together, and may be formed into cables.

[0115] Referring now to FIG. **6**A, FIG. **6**B, and FIG. **6**C, and with continued reference to FIGS. **1**-**5**C, there are shown portions of additional SMA working element forms, which are spring-based SMA working elements. Features and components shown and described in other figures may be incorporated and used with those shown in FIGS. **6**A, **6**B, and **6**C.

[0116] Spring-based heat engines may be capable of running over a large range of operating conditions. The compliance (ability to longitudinally deform through normal spring motion separately from the crystallographic phase changes) of the spring acts as an overload prevention mechanism. Furthermore, the geometry of coiled springs provides relatively high friction around drive pulleys.

[0117] FIG. **6**A shows a portion of an SMA member **222** that is formed as one or more springs **223** joined into a loop. Note that the portions shown in FIG. **6**A may actually be the two ends of a single, looped spring **223**.

[0118] A fiber core **225** is placed within the coil of the spring **223** and runs throughout the loop created by the SMA member **222**. Fibers—including, for example, aramid or para-aramid fibers—are inserted through the coil of the springs **223** to keep the coils in their intended path. Aramid fibers are a group of synthetic fire-resistant and strong polyamides used to make textiles or plastics.

[0119] Other elements may be placed within the coil of the SMA springs **223** to support the coil, prevent it from getting slack, and retain the coil during failure. When multiple springs **223** are used, the fiber cores **225** may also prevent some SMA springs **223** from loosening when cooled, which could potentially allow separation of one of the springs **223** from the remainder of the SMA member **222**.

[0120] A weld region **227** demonstrates one technique for joining the ends of spring-type SMA working members or elements. The weld region **227** utilizes an interlocking portion of the springs **223**. For example, the two ends are threaded into each other, and the weld is created along the seam between the two ends. This joining technique creates a more robust joint by placing the weld region **227** in partial compression.

[0121] Welding along the seam of the springs **223** also takes advantage of the lap welding method, which can be more robust than a butt weld in this configuration. Additionally, the weld region **227** may be formed such that the weld is only on the inside seam (as opposed to welding both inside and outside, as shown). Welding the seam along the inside circumference of the springs **223** may improve the joint formed at the weld region **227**. The interior-only welding method may also better preserve the geometry of the individual springs **223** and the SMA member **222**.

[0122] FIG. **6**B shows a portion of an SMA member **262** that is formed from two springs, a first spring coil **263** and a second spring coil **264**, placed and threaded in coaxial alignment with each other, such that each individual loop is working in parallel with the other individual loops. The second spring coil **264** is shown with dashed lines to better illustrate the two separate springs of the SMA member **262**. A fiber core **265** is disposed within both the first spring coil **263** and the second spring coil **264**. The second spring coil **264** is overlapped in parallel with the first spring coil **263**, such that both are generally aligned along the same axis around the same fiber core **265** and will expand and contract in tandem.

[0123] Additional spring coil elements may further be arranged in parallel. Note that because the spring-form elements expand, numerous additional coils may be threaded or wound in parallel and the SMA member **262** will still expand or stretch when in operation on an SMA heat engine, such as the heat engine **14** or the heat engine **64**.

[0124] The first spring coil **263** may be used to form a first loop at a first joint (such as a weld joint) and the second spring coil **264** may be used to form a second loop at a second joint. The first joint may be offset from the second joint such that the joint locations of the each of the loops are not aligned. For example, and without limitation, the joints may be offset by at least ninety degrees relative to the path of the SMA member **262**. Note that as the number of spring coils used is increased, the distance (whether linear or rotational) between each of the coils may be reduced. As used in this instance, three hundred and sixty degrees equals one complete loop around the loop of the SMA heat engine into which the SMA member **262** is incorporated.

[0125] FIG. **6**C shows a portion of an SMA member **282** that is formed from two interleaved springs, a first spring coil **283** and a second spring coil **284**. In the SMA member **282**, the first spring coil **283** and the second spring coil **284** are aligned or arranged in parallel with their respective axes slightly offset. The first spring coil **283** and the second spring coil **284** are also interleaved, such that portions of the coils of the first spring coil **283** are wound through portions of the coils of the second spring coil **284**.

[0126] A first fiber core **285** is disposed within the first spring coil **283** and a second fiber core **286** is disposed within the second spring coil **284**. The first fiber core **285** and the second fiber core **286** may be ararmid materials. The first spring coil **283** and the second spring coil **284** generally form an SMA belt or ribbon that is wider than it is thick. Additional spring coil elements may further be arranged to widen the ribbon and make the SMA member **282** much wider than shown.

[0127] For large SMA heat engines, spring-form SMA can be scaled-up in material density by intertwining multiple springs such that they form a wide mesh ribbon or belt. This may help ensure that failure of a coil would not eject the broken coil into the heat engine or surroundings and may improve the integrity of the SMA member **262**.

[0128] Further modification of the SMA members **222**, **262** may occur through adjustment of the helix angle of the springs **223**, **263**. Alternatively, the coil diameter may be adjusted and may be matched to the type of pulley used in the heat engine into which the SMA members **222**, **262** are incorporated.

[0129] Similar to the SMA working elements shown in FIGS. **5**A, **5**B, and **5**C, the spring-based SMA working elements may be combined into belts for use in large-scale energy production. For example, the springs **223**, **263** may be tacked together to form flat, planar belts or multiple springs